Morphodynamic Feedbacks during Vegetation Colonization of Tideflats

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LONG-TERM GOALS

The long-term goal of this effort is to understand interactions and feedbacks between biotic and physical process in tideflat morphodynamics. Investigated biotic processes will consist primarily of vegetation colonization of tideflats, although benthic infauna could also be an important consideration under some circumstances. Physical process include those related to hydrodynamics, such as flow, sediment transport, salinity regime, inundation period, wave/storm disturbance, flood disturbance.

An additional subsequent goal is to apply an improved understanding of tideflat morphodynamics to system management, e.g., [1] to anticipate and plan for the effects of sea-level rise and other climate-change effects on system hydrodynamics, sediment dynamics, and landscape-scale ecology; [2] to plan for potential habitat restoration, particularly the restoration of historical river distributaries in the delta; or [3] to anticipate system impacts from engineering efforts, such as a system-scale flood management project proposed by the US Army Corps of Engineers.

OBJECTIVES

1. To describe early vegetation colonization process in sandy tideflats. This would include determining rates of change, vegetation species involved, successional patterns (if any), and changes in tideflat biophysical structure, e.g., canopy density and height (in anticipation of these parameters being used in hydrodynamic models).

2. To discern physical controls on the colonization process, e.g., topography, sediment quality, hydrodynamics, salinity regime.

3. To discern physical consequences of vegetation colonization, e.g., direct and indirect topographic responses, including possible channel formation or stabilization and changes in sediment quality.

APPROACH

The project approach includes GIS change analysis, RTK-GPS topographic surveys, a space-for-time substitution sampling design, quantification of vegetation and sediment quality, and development of conceptual and statistical models of colonization processes and consequences.

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GIS change analysis will identify patterns and rates of channel change and vegetation development. It will include analysis of orthophotos from 2000, 2001, 2004, 2006, 2007, and 2009 with pixel resolution ranging from 15cm to 45cm. It could also include analysis of aerial photos that will be acquired monthly by Chris Chickadel and Jim Thomson of the Applied Physics Laboratory of the University of Washington, depending on the resolution of the photos.

RTK-GPS topographic surveys will identify the topographic circumstances that characterize the locations of various species of marsh vegetation, on new islands as well as reference marshes. Additionally, these surveys (at 0.25 to 1.0 m grid resolution depending on island size, and 2 cm horizontal, 3 cm vertical accuracy) will identify topographic features and patterns associated with colonizing vegetation, e.g., horseshoe scour channels and deposition tails (Fig. 1). The RTK-GPS survey may also be supplemented with ground-based LIDAR provided by Eric Grossman of the USGS Coastal and Marine Geology Division (Santa Cruz), depending on the availability of the equipment.

Quantification of vegetation and sediment quality includes measurement of vegetation stem density and canopy height, and measurement of sediment grain size, pore-water salinity, and organic content.

WORK COMPLETED

The project was initiated in July 2008, so the work completed so far represents a preliminary and initial effort. It focuses on the North Fork Skagit River tideflats near the outlets of the North Fork distributaries. It includes digitizing the sandflat tidal channels in the 2004 orthophotos in this area, initial digitization of the 2007 tidal channels, preliminary RTK-GPS survey of marsh and newly colonized island elevation and dominant vegetation (660 data points collected so far), measurement and GPS mapping of sediment pore-water salinity (at a grid resolution of 160m) in the tideflats within 1200m of the distributary outlets, and preliminary development of a conceptual model. Additionally, we coordinated project logistics with other Tide Flats DRI investigators, e.g., those staging out of the Swinomish Reservation. This was a particularly successful effort and the staging area will be expanded next summer to accommodate an expanded presence and effort by Brit Raubenheimer and Steve Elgar (and their staff/students) from WHOI.

RESULTS

Initial field surveys suggest a characteristic topography is associated with new or growing marsh islands in the tideflats. These include horseshoe-shaped scour channels at the upstream end of the new island and deposition of fine sediments at the downstream tail of the island (Fig. 1). This appears to occur over a scale of at least 2 orders of magnitude,

Figure 1. Horseshoe scour and deposition tail (smooth ridge to right of island) associated with new Schoenoplectus americanus island at low tide. Survey rod in foreground = 1.5 m. Dominant flow is from left to right.

having been observed for an island as small as 2m long and one as large as 115m long. In the case of the large island, the depositional tail is currently occupied by low-density colonizing vegetation, suggesting a subsequent stage of marsh island growth following establishment of the initial vegetated island, currently characterized by high-density vegetation. Similar topographic patterns have been observed in braided fluvial systems except that islands in these systems are initiated by the deposition of large logs with root wads (Gurnell et al. 2005). Another significant difference, of course, is that flow in tidal systems is bi-directional. Nevertheless, the fluvial model may be a useful analog.

Initial surveys of vegetation and elevation suggest *Carex lyngbyei* (Lyngby's sedge) and *Juncus balticus* (Baltic rush) are the most common colonizing species and colonize flats at much lower elevations than at which they occur in mature marsh communities (Fig. 2). *Schoenoplectus americanus* also colonizes tideflats to form new islands, but the sample size was too small to derive even preliminary inferences. This result is surprising, especially in the case of *Juncus balticus* which is more typical of much higher marsh elevations. It remains to be seen why vegetation normally found at higher elevation in reference marshes colonizes significantly lower sites on tideflats. Possible explanations might invoke physical factors (differences in sediment quality that affect soil drainage and saturation) of ecological factors (competition, seed availability, site conditioning and facilitation). At first glance reliance on a purely physical explanation seems likely to be unsatisfactory. The possible physical mechanisms for lowering the elevational constraints on *Carex* and *Juncus* should presumable function similarly to lower those requirements for other species found growing at still lower elevations in reference marshes, e.g., *Cotula*, *Schoenoplectus*, *Deschampsia*, *Triglochin*. Yet these species were (as of yet) not found colonizing sandflats at lower elevations. Resolution of this apparent paradox should lead to interesting new insights in vegetation colonization in these habitats.

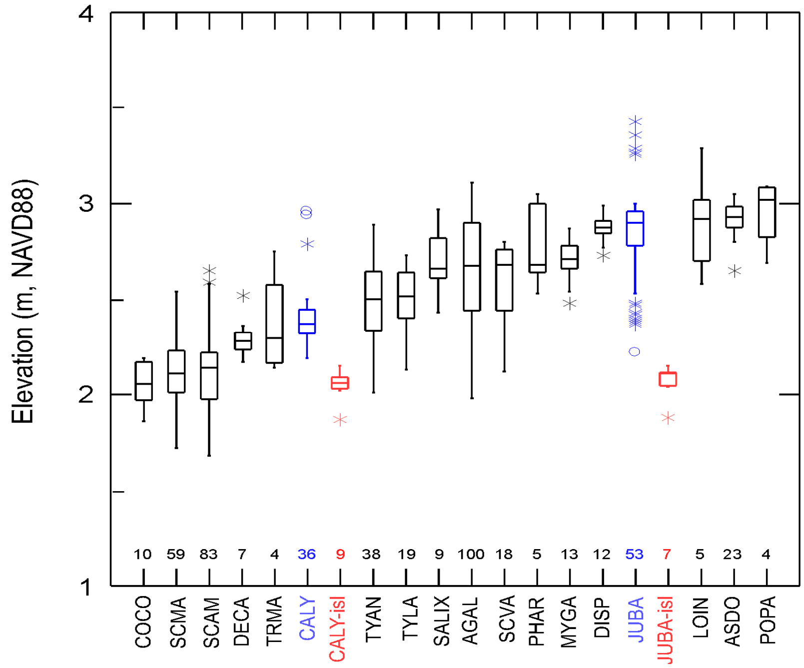

Figure 2. Box plot of preliminary survey of tidal marsh vegetation in the reference marsh (black and blue) vs. newly colonized islands (red). Horizontal bar = median elevation, top box edge = 3rd quartile, bottom box edge = 1st quartile, vertical bars = 1 SD, * = points within 2 SD, 0 = outliers. Sample size appears below each box plot. Carex lyngbyei (CALY) and Juncus balticus (JUBA) appear to be the most common colonizing species and colonize flats at much lower elevations than at which they occur in mature marsh communities.

Finally, I have begun digitizing tideflat channels in a GIS using available aerial photographs. This has been completed for the 2004 photos of the North Fork flats. When the 2004 channels are overlaid on the 2006 or 2007 photos (Fig. 3) it is apparent that there have been significant changes over this time span. Even a very large river distributary has dramatically shifted course between 2004 and 2006, emphasizing the dynamic character of this system and providing some indication of the short time scale over which very significant channel changes may occur. It is possible with the monthly imagery that will be provided by Jim Thomson and Chris Chickadel that these dynamics will be seen to have a seasonal pattern, perhaps associated with seasonal river floods or with storms and the waves they generate.

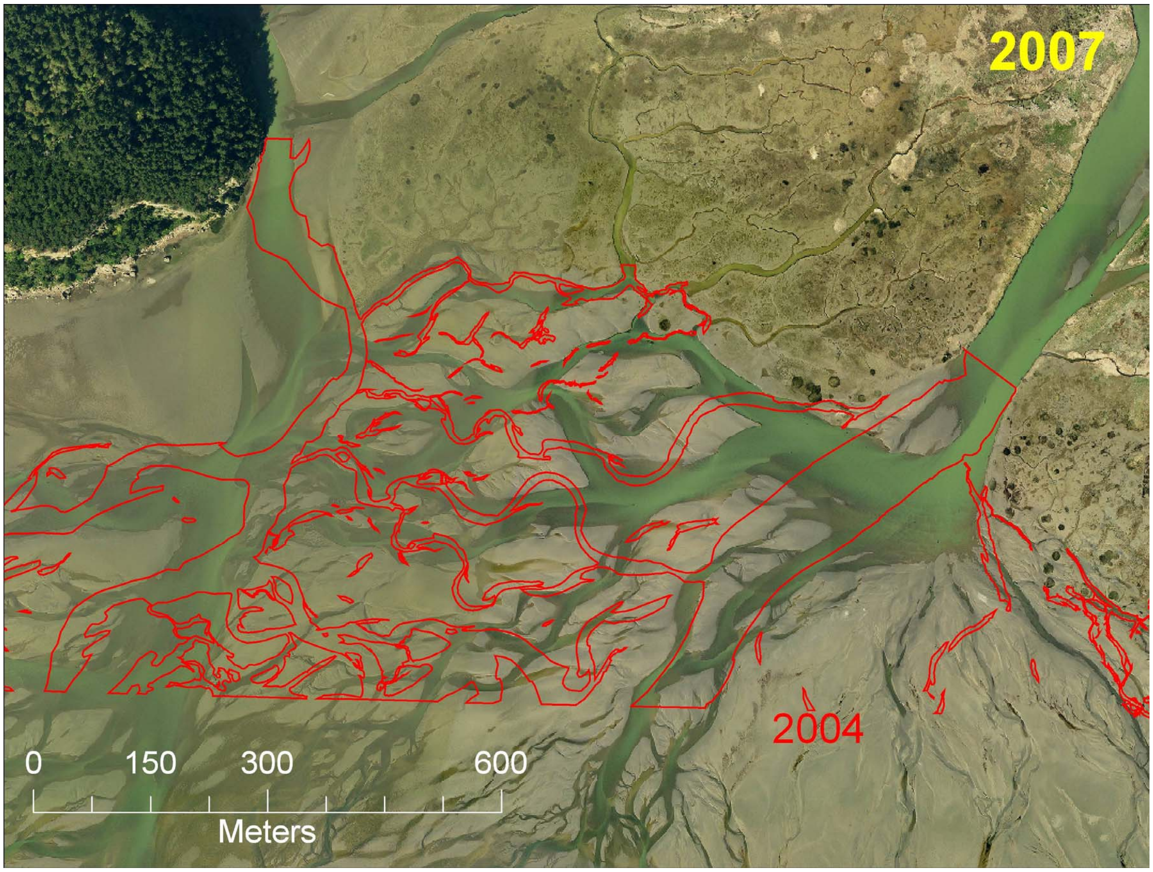

Figure 2. 2004 tideflat channels (red polygons) on the 2007 aerial photo. The limit of the 2004 photo coverage is marked by the straight border of the 2004 data. Over a three year period the channels have been very dynamic, including the major distributary coming in from the upper right of the photo. It now bends sharply to the west (left) rather than continuing south as in 2004. Digitizing other year-sets, including 2009, is planned.

IMPACT/APPLICATIONS

This project will generate measurements of parameters that can be used to model hydrodynamics and sediment transport in the presence of intertidal vegetation. It will also generate conceptual models and hypotheses that can be used to focus future investigations and model development. In addition to immediate application to development of hydrodynamic models, this work will provide useful insights and guidance for system management, e.g., [1] to anticipate and plan for the effects of sea-level rise and other climate-change effects on system hydrodynamics, sediment dynamics, and landscape-scale ecology; [2] to plan for potential habitat restoration, particularly the restoration of historical river distributaries in the delta; or [3] to anticipate system impacts from engineering efforts, such as a system-scale flood management project proposed by the US Army Corps of Engineers.

RELATED PROJECTS

This project is related to other DRI projects (http://www.tidalflats.org/) located in the Skagit Delta, particularly those involving Jim Thomson and Chris Chickadel (Applied Physics Laboratory, University of Washington), Eric Grossman (USGS, Santa Cruz), Steve Henderson (Washington State

University), and Brit Raubenhiemer and Steve Elgar (WHOI) all of whom are working in the North Fork area where much of this preliminary work has taken place.

A potential future collaboration could occur with Brian White (UNC-Chapel Hill) who is interested in modeling hydrodynamics and sediment transport in vegetated marshes and incipient marshes.

REFERENCES

Gurnell AM, K Tockner, P Edwards, G Petts. 2005. Effects of deposited wood on biocomplexity of river corridors. *Frontiers in Ecology and Environment* **3:**377-382.